Exploration Brief

Absorption and Radiation

Context

The temperature range of outer space and on planetary bodies is affected by a wide range of factors. In outer space, the temperature on a surface depends upon whether that surface is in sunlight and if so, the angle of that surface to the Sun's rays. On a planetary body, the temperature also varies with the ambient atmospheric temperature, winds, and nearby surface materials. For example, on Earth temperatures can vary dramatically on a summer day between asphalt parking lots and grassy borders.

When designing spacesuits, it is important to account for the temperature range of the environment for which the suit is intended. Heating and cooling systems inside a suit can moderate temperatures, but electric power to operate these systems limits the length of time the suit can be used before recharging. One way to reduce the dependency of a spacesuit heating/cooling system is to use materials for suit construction that have desirable thermal properties. If, for example, a suit is operated in a very cold environment, good insulating material will reduce the need for internal suit heating.

Materials and Tools Checklist

- ☐ Coffee cans with plastic lids
- ☐ Thermometers
- ☐ Flood lamp (optional)
- ☐ Various colors of paint
- ☐ Foil, construction paper, etc.
- ☐ Clock
- ☐ Refrigeration (see step 6)

Objective

• To investigate the effect different colors, reflective surfaces, and different materials on radiant heat absorption and heat radiation.

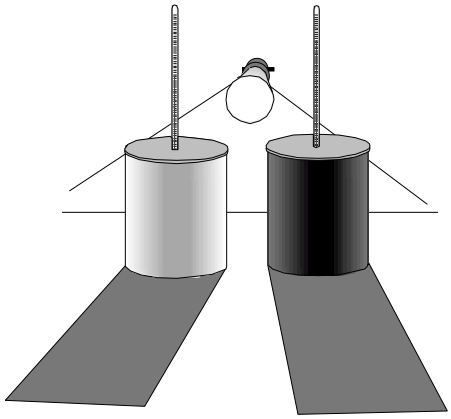
Investigation

Surface Color

This activity investigates the affect surface color has on heat absorption and radiation.

Procedure

Step 1. Paint the surfaces of several coffee cans in different colors such as white, black, green, or yellow.



Step 2. Punch a small hole in the plastic resealable lid and insert a thermometer bulb to approximately the middle of each can.

Step 3. Place the cans in sunlight so that all are equally exposed. Immediately record the initial temperature of each can. If you are doing the experiment inside, expose the cans to a flood light. It is important that each can receives the same amount of heat from the lamp. Measure and record the temperature of the cans every minute.

Step 4. Remove the cans from the heat source after 10 minutes and measure and record their temperatures again for the next 10 minutes. Graph your data. Relate the temperature rise and fall of each can to its surface color.

Step 5. Change the surface material of the cans by wrapping them with aluminum foil, gray construction paper, or cloth.Repeat the experiment to find the best combinations of colors and surfaces for different environments.

Step 6. Repeat the experiment by subjecting the cans to intense cold. The cans can be placed in a freezer or in a tub with ice water or a block of dry ice.

Investigation

Insulating Layers

In this activity, students explore the insulative properties of several materials.

Step 1. Stack different fabrics, paper, and foils, and fold them into small envelopes. Insert a thermometer and repeat the previous experiment to determine the heat absorption and reflection properties of different material combinations.

Extensions

- Conduct chromatography experiments on various ink colors to see what their component colors are. Black inks often consist of several colors. The reason for mixing several ink pigments is to make a darker black (more complete absorption of light). (The Space Shuttle uses black heat shield tiles on the bottom of the orbiter to quickly dissipate the heat produced when reentering Earth's atmosphere.)